Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project

TEAM: Chevron Technology Ventures, Hyundai-Kia Motor Company & UTC Power

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Chevron Hydrogen

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This presentation does not contain any proprietary or confidential information

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Overview

Timeline

- Start: January 15, 2004
- End: September 30, 2009
- 85% complete

Budget

Total project funding	**$94.5 mil**
• DOE share	$38.1 mil
• Contractor share	$56.4 mil
Funding received in FY08	**$ 5.8 mil**
Funding for FY09	**$ 2.9 mil (est)**

Barriers

- Fuel cell vehicles data
- H_2 refueling infrastructure data

Team Members

- Hyundai-Kia motor companies
- UTC Power
- Hyundai Kia America Technical Center
- Alameda Contra Costa Transit
- Tank Automotive Research, Development and Engineering Center (DOD)
- Southern California Edison: Site Host

Objectives – Relevance: Technology Validation 2009 Decision Criteria

- **Demonstrate safe, practical hydrogen technologies in real-world settings**

  http://investor.chevron.com/phoenix.zhtml?c=130102&p=irol-newsArticle_print&ID=676776&highlight

  - Validate complete systems of integrated hydrogen and fuel cell technologies for transportation, infrastructure and electricity applications under real-world operating conditions

    http://www1.eere.energy.gov/hydrogenandfuelcells/mypp/pdfs/tech_valid.pdf

- **33 fuel cell vehicles collecting durability and range data on the road**
  - 2000 hr fuel cell durability
  - 250 mile vehicle range
- **Public–private partnership of five on-site generation hydrogen stations**
  - $3.00/gge production cost
- **24/7 safe fueling by trained drivers**
  - Safe and convenient refueling by drivers

Collaborations - Partners

Within DOE Tech Val Program

Project Lead

Chevron hydrogen

Cost Share Provider

Light Duty Vehicle Technology Providers

HYUNDAI · KIA MOTORS

UTC Power
A United Technologies Company

Site Hosts and Vehicle Operators

SOUTHERN CALIFORNIA EDISON
An EDISON INTERNATIONAL Company

Hyundai KIA America Technical Center, Inc.

AC TRANSIT

Not part of DOE Tech Val Program

Infrastructure data reported to NREL at no cost to DOE

Bus Technology and Funding

VANHOOL

ISE
Transportation recharged.

Site Host

Progress Energy

Vehicle Operators

ORLANDO INTERNATIONAL AIRPORT

SeaWorld ADVENTURE PARK Orlando

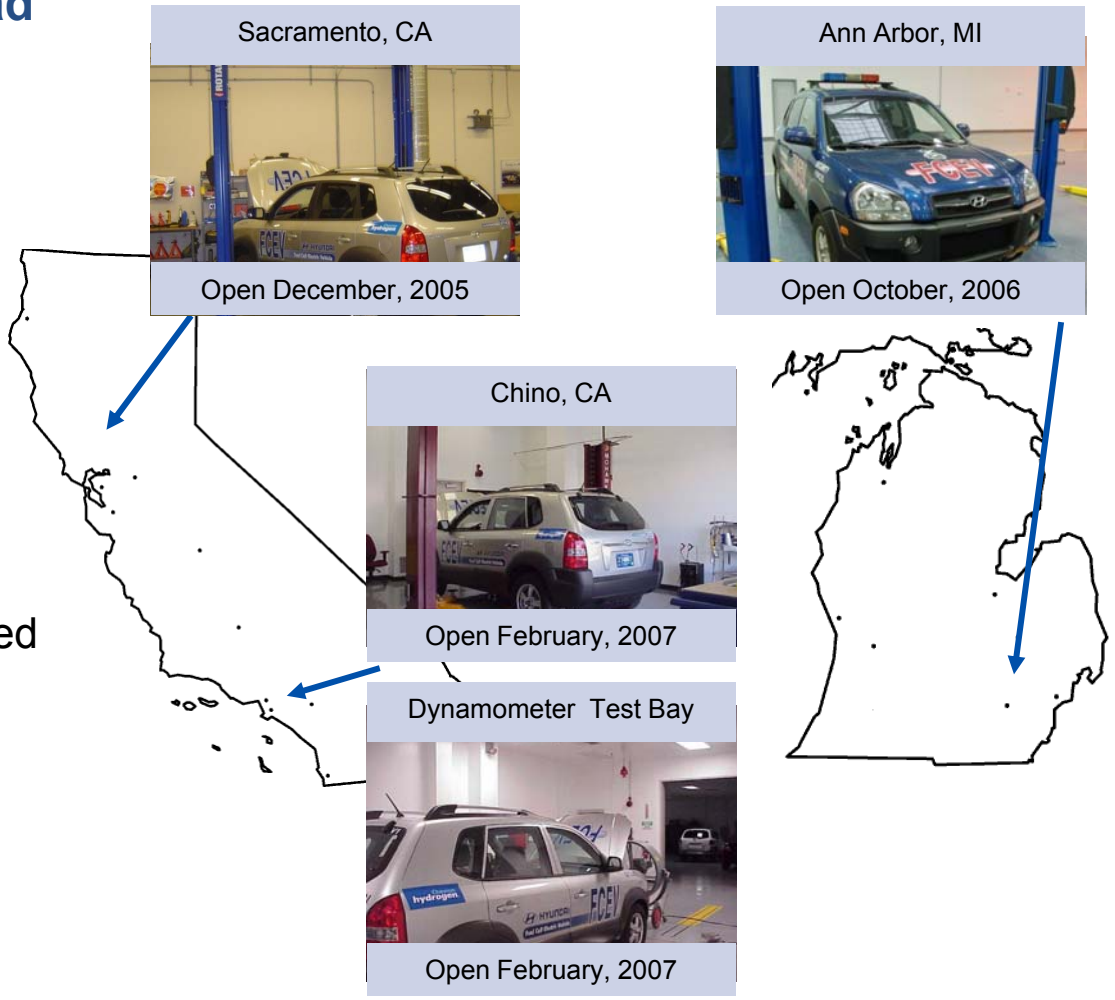
ORANGE COUNTY GOVERNMENT FLORIDA

Approach - Infrastructure

- **Five stations in operation**
  - Varied climates
  - Varied capacities
- **On-site generation**
  - Six technologies employed
  - Two technologies at Oakland
  - Two new technologies
  - Developed for DOE program
- **Private – Public partnership**
- **Controlled fleet**
  - Match production with usage
- **Third-party fuelings available**

Approach – Vehicles and Maintenance Facilities

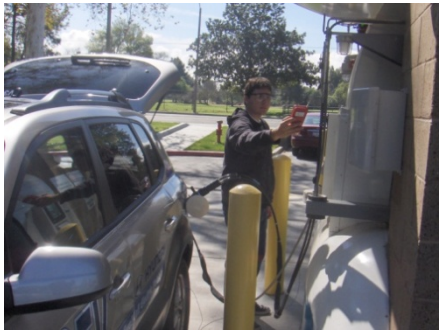
- **Thirty-three vehicles on the road**
  - Collect statistical data:
    - 2,000 hour fuel cell durability
    - 250 mile range
    - Cold start capability at -20C
- **Three maintenance facilities**
  - Personnel trained
  - Maintenance procedures developed
- **One dynamometer test bay**



Progress – Driver Training

Driver fueling training

- **350 bar fill**
  - Communications cable
  - Nozzle connection
  - Gas leak testing
  - PIN access
  - Data recording



- **700 bar fill UC Irvine**
  - How it works
  - Do's and don't 's
  - Fueling process

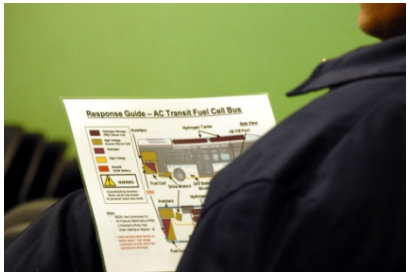
Hydrogen Energy **Human Energy**

Progress – Hydrogen Training

Operator training

- **Station maintenance**
  - Compressors
  - Generators
  - High pressure fittings
  - Dispenser hose and nozzle

- **First responder training**
  - Offered at all stations yearly
  - Refresher training
  - Train new hired personnel
  - Station and vehicle safety



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Technical Accomplishment – Cold Weather Start-Up

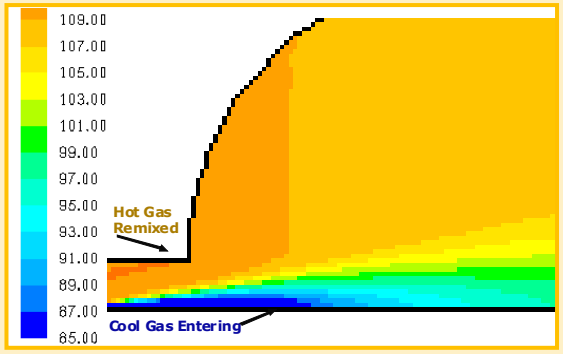
Drive away

Start-up

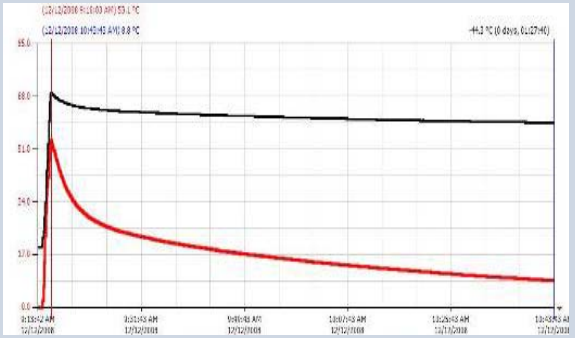
Parked outside overnight

Technical Accomplishment - Vehicle Tank Temperature Sensor Location Test

- **Temperature during fueling**
  - Varies with location in tank, fill rate and time
- **Temperature sensor dual function**
  - Input for density calculation
  - Over temperature safety measurement



- **Cooling experiment**
  - Conduct fill
  - Record temp and press while cooling
  - Calculate density till "equilibrium" reached

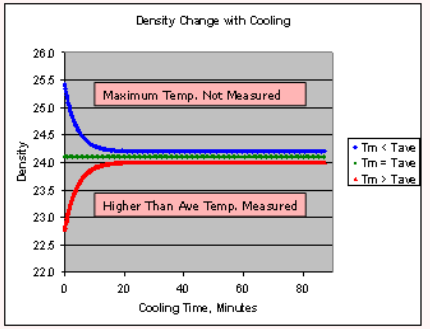


- **Density change while cooling**
  - Flat line density;

    measured temp = average temp
  - Higher density;

    measured temp < average
  - Lower density;

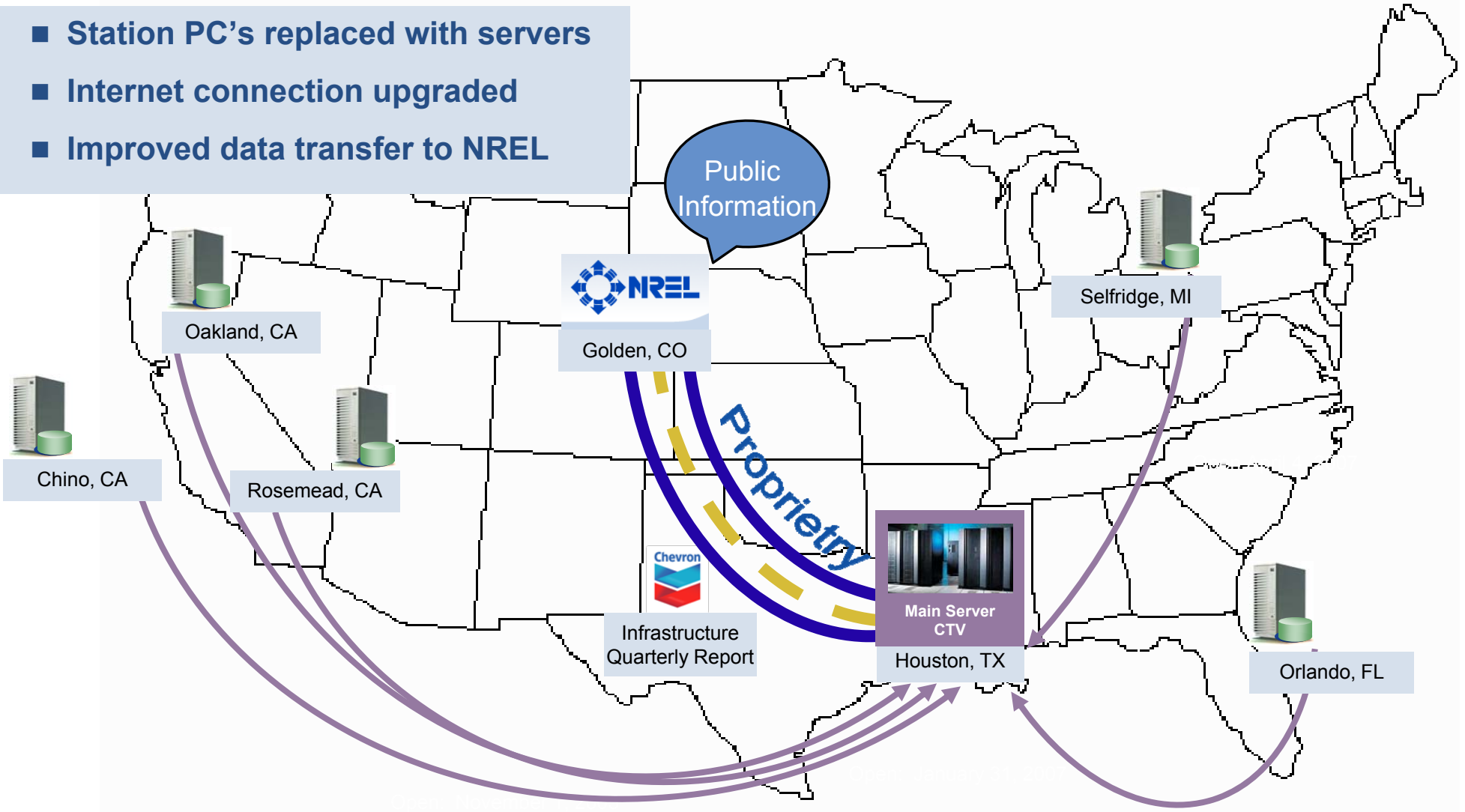
    measured temp > average



Determines if sensor is located in "hot spot"

Progress – Infrastructure Data Transfer

- **Station PC's replaced with servers**
- **Internet connection upgraded**
- **Improved data transfer to NREL**



Technical Accomplishment – Station Efficiency

Daily station mass balance (100 +- 2%)

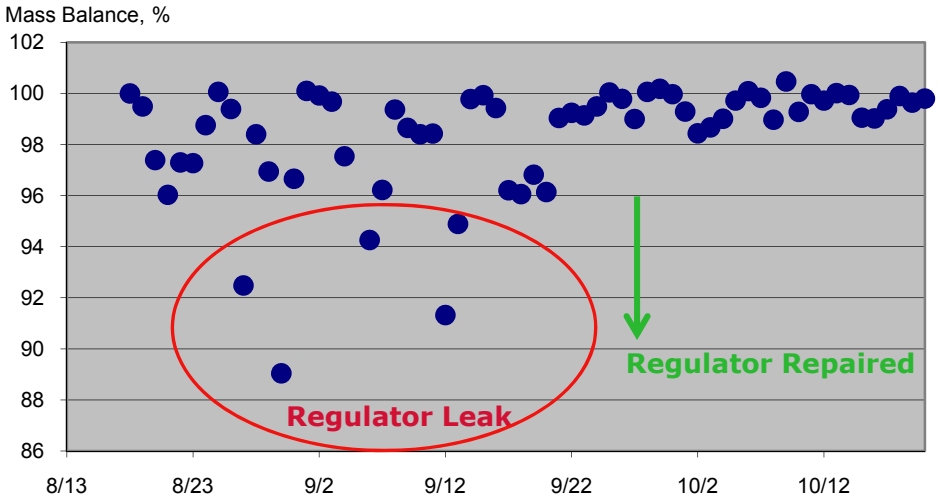
- **Identified system leaks**
  - Oakland regulator leaking to vent
  - Regulator replaced
  - Mass balance restored

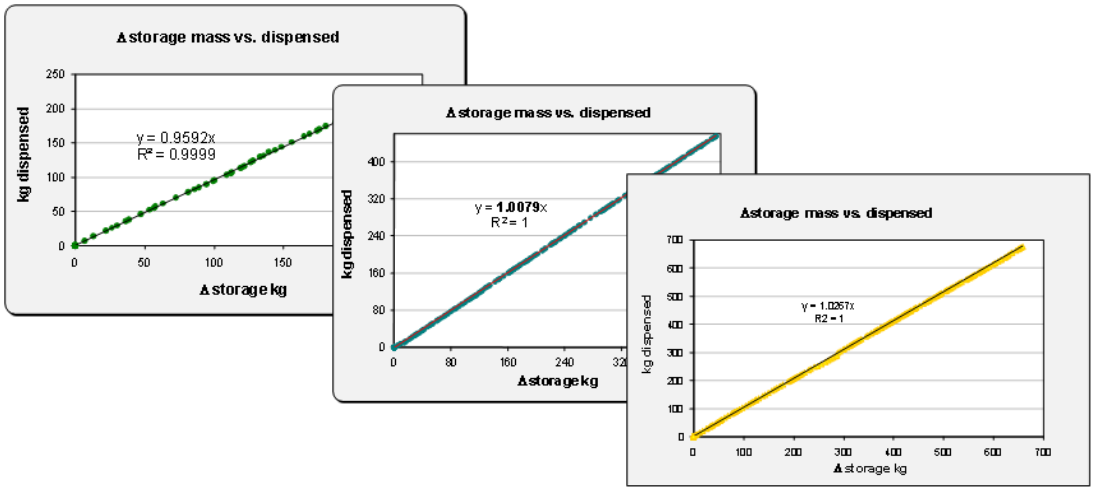
Efficiency calculation

- **Requires mass balance for accuracy**
- **Account for system losses**
  - Boil off liquid systems
  - Vapor leaks gas systems

Dispensing/storage mass balance

- **Compare**
- **Kilograms dispensed vs. change in storage inventory**
  - Agreement after more than 1000 kilograms dispensed





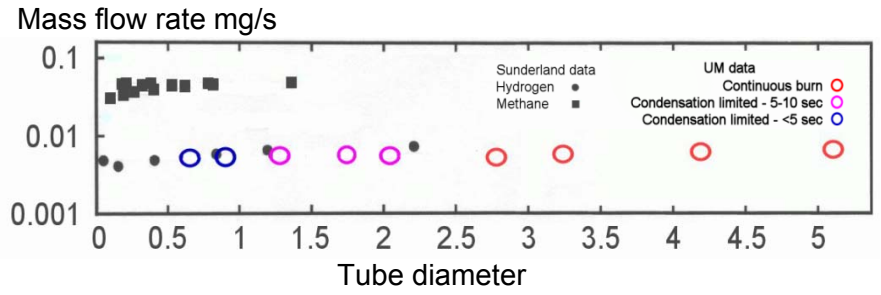
Collaboration – U of Miami Hydrogen Modeling

Mapping ignitability of H2/Air mixtures

- Constructed unshrouded, 0.270” gap, 3.0 Joule igniter which produced consistent ignition of 4.5% H_2 in air
- Constructed reducing ignition energy to 0.75 joule produced a reduction in ignition probability

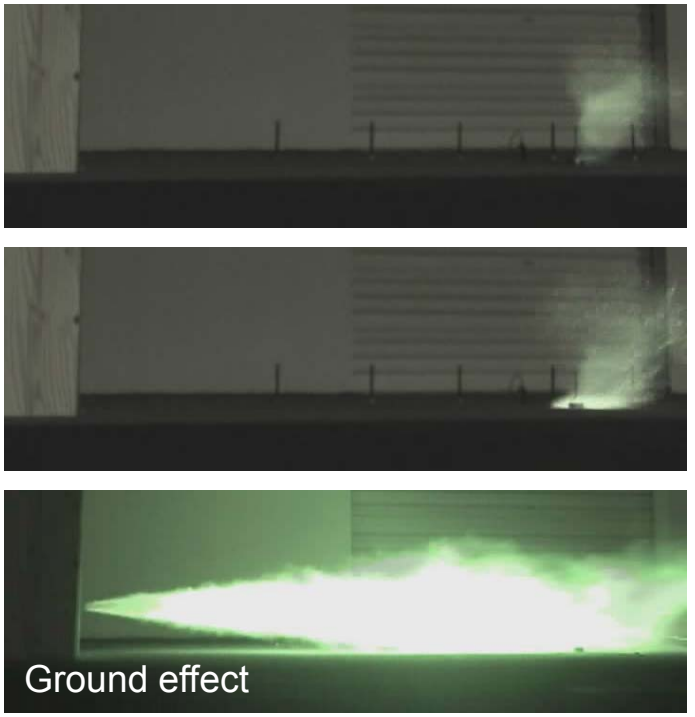
Standing flame testing

- Comparison to Peter Sunderland work
- Identified water condensation effect



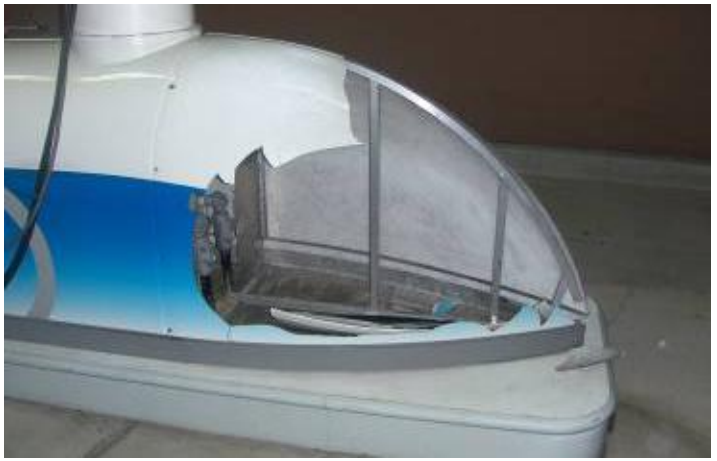
CFD modeling of hydrogen storage leak

- Full scale hydrogen leak ignition tests show the necessity for further corrections to the model to improve behavior in close proximity to the ground



Lesson Learned – Accident at Dispenser Island

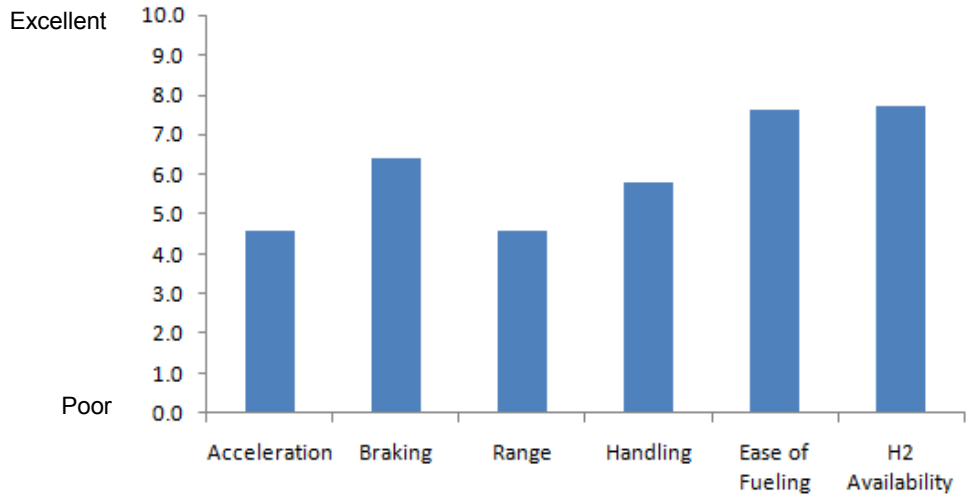
- **Dispenser safety systems**
  - Bollards; motion sensor; gas detector; shut-off valves
- **Bus backs into monorail**
  - 1:45 AM 11/14/08
  - Damage to monorail
  - No damage to dispenser
- **Thorough inspection of dispenser**
  - Minor leak observed
  - Leak repaired, dispenser returned to service



Lessons Learned – Customer Feedback

- **Survey**
  - Fuel cell vehicle and hydrogen station performance
    - Current and former drivers
    - Fuelers
  - Feedback applied to future work

Vehicle and station performance survey results



100% of drivers surveyed would participate in another program

- **"Demonstrations are necessary to get this technology off the ground"**
- **"The programs give the OEM opportunity to learn what customers want…I expect driver input will have a positive affect on the next generation FCVs"**
- **"I have had many positive experiences with hydrogen cars and stations,…"**

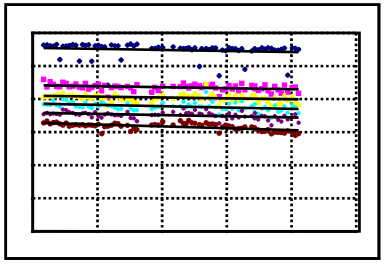
Hydrogen Energy **Human Energy**

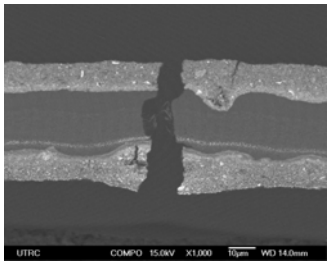
Future Work

- **Collect operating data from generators at all five stations**
- **Collect data from on road vehicle operation**
- **Publish**
  - U Miami report
  - Economical viability topical reports

- **Deploy twelve fuel cell buses**
  - UTC Power PureMotion® PM 120 power plants
  - Operation at AC Transit Oakland and local agencies

- **Continue UTC technology development internally and with OEMs**
  - Advancements in durability
  - Reduction in Pt loading
  - Improvement in power density
  - Cost reduction of stack components
  - Freeze capability





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DOE Hydrogen Program

Future Plans – Hyundai-Kia New FCV vehicles

3rd Gen FC SUV's

- **Phase 1: Deploy 26 in Korea**
- **Phase 2: Deploy 100+ in Korea, Deploy 50+ in USA**

3rd Gen. Tucson/Sportage Hyundai 100 kW stack

3rd Gen. Borego SUV Hyundai 115 kW stack

Fuel Cell Concept Vehicle

- **Designed for fuel cell from ground up**
- **Future generation Hyundai fuel cell technology.**
- **System: 100kW stack power**
- **70MPa compressed hydrogen.**
- **Vehicle performance 370 mile range**

I-Blue

I-Blue Chassis

Program Summary

- **Relevance**
  - Demonstrate safe, practical hydrogen technologies in real-world settings
  - Not in the lab or on a test track – On the road and in communities
- **Approach**
  - Fleet testing of 33 FC vehicles – Collect on road data for 2000 hr durability and 250 mile range
  - Operate six on-site hydrogen generators – Introduce new distributed generation technology
- **Technology transfer**
  - Public-private partnerships
- **Technical accomplishments and progress**
  - Safe fueling by drivers
  - Cold start-up
- **Proposed future work**
  - Continue demonstration of vehicles and infrastructure data reporting to NREL